Summary of Liquid Argon TPC R & D plan October 25 2006

In answer to the message from the NuSAG chairs to the Long Baseline chairs ..... *we would like to have the following by Monday, October 23 2. For LAr: A short report on liquid argon detectors focused on the R&D needed to build and cost a large detector – 50-100 kt if that is what is required to do the science. Give us an R & D plan - what technical progress must be made and how long do you plan for each step to take. If you can, give us an idea of the cost of the R & D plan and estimates of the cost of the full scale detector if either of these costs is available.*

R & D plan towards costing and building a 50 - 100kt liquid argon TPC

There are three aspects to our plan for R & D for costing and building a 50 - 100kt detector. They are conditioned by two considerations. One is the need to develop hands-on experience with Liquid Argon TPCs in the US. The other is that while the ICARUS collaboration has demonstrated the viability of the technique and has succeeded in building and operating a 300 ton device, a cost-reduction of a factor of about 10 is required [1] to make a 50 - 100 kt detector economically possible. This latter requirement implies a new approach to the construction of the major cryostat, one in which it is not feasible to evacuate the vessel to remove the air. Since long electron drift lifetimes are critical to the operation of a liquid argon TPC, this is perhaps the most important single hardware issue to resolve.

We concentrate here on the hardware aspects of our R & D since this is what NuSAG has expressed most interested in. We should like, however, to mention that the DAQ and pattern recognition are also challenges that will require significant attention for a successful detector.

The three aspects of our R & D plan can be summarized as:

(1) Develop hands on experience and understanding of basic liquid argon technology; these include:

- the purification process to achieve argon with long electron drift lifetimes
- low-noise electronic and electrical systems required for readout by seeing tracks in a small (50 liter) TPC
- qualification of materials appropriate for construction of the detector
- achievement of long drift times without evacuating the TPC volume

(2) Construction of $\sim$ 3 ton module to test design concepts for large devices - specifically a cylinder 5 meter long and 1 meter in diameter that can be used both to demonstrate long drifts and a TPC wire system based on the panel concept [2].

(3) Design and construction of a detector large enough to serve as the next step to the 50 -100 kt detector.

While these projects define the main hardware R & D line, it is important at this stage to invest some time in new technologies which could have major positive impacts on the design. An example is the development of electronics (preamplifiers and multiplexers) which operate in the body of the liquid argon. This could improve the signal to noise by removing the cable capacitance (typically 1/2 the total at present), lower the number of feed throughs required and permit schemes where the wires do not have to be read out at the top of the vessel.

Schedule and Costs:

Project (1) is in full swing and is designed to be complete by July 2007. The cost in M & S to develop the required infrastructure over two years has been a total of about \$400k at Fermilab and \$100k at Yale.

The design of project (2) has started. Depending on funding to procure the cryostat, and manpower, the system should be ready for commissioning towards the end of 2007. The estimated cost in M & S is \$500k.

Candidates considered for the detector for Project (3) include a $\sim$ 1 kt device at Fermilab and larger devices ($\sim$ 3 to 10 kt) at Soudan or Ash River. Each of these has its advantages in terms of advancing the technology (both hardware and software) and the physics. The $\sim$ 1 kt device would be a technology development project with tens of thousands of beam neutrino events for analysis. The larger devices would have an oscillation physics program to complement NOνA. At present there are internal discussions and discussions with Europeans (particularly from INFN) to produce an LOI for one of these options. Once an option is chosen, we would like to start on the design for Project (3) immediately. The design will follow the techniques proposed for a 50 - 100 kt device and thus provide both a full design for the LOI detector and a credible cost estimate for larger detectors. The construction of the detector for Project (3) is expected to cost (M & S) \$10M for the $\sim$ 1kt detector; the larger options range from \$20M (3kt) to \$50M (10kt). We expect the design would take a team of engineers and physicists one year and would be informed by the results obtained from the ongoing R & D. The start of construction of Project (3) will depend on completion of the design, the successful completion of Projects (1) and (2), and support from the funding agencies to commit to this technology.

We should like to note that while this summary covers our present R & D hardware plan, it does not, of course, cover all our hardware activities. In particular, we are in contact with experts on liquid argon in Europe who also have ongoing R & D projects, and there is a Yale/FNAL test beam project in the planning stages to expose a 300 liter (0.4 ton) LArTPC to the NuMI beam.

References

[1] The cost of (the recently cancelled) T1200 project is taken as \$25M.

[2] See http://lartpc-docdb.fnal.gov/cgi-bin/ShowDocument?docid=199.